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REACTIVITY OF THE ORGANISM DURING LONG DURATION SPACE FLIGHTS

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REACTIVITY OF THE ORGANISM DURING LONG DURATION SPACE FLIGHTS

P. V. Vasilyev

ABSTRACT. It has been established that weightlessness and hypodynamia produce certain changes in the function of circulation, respiration, excretion, the analyzer and regulatory systems as well as in various metabolic processes. The reorganization of these systems leads to changes in total reactivity closely related to body resistance. This paper presents an analysis of the literature data and authors' findings, indicating that weightlessness and hypodynamia result in reduced orthostatic and vestibular tolerance, increased susceptibility to infection, decreased resistance to acceleration and physical exertion, and altered reactivity to drugs.

As we know, extended space flights will be accompanied by the effects of quite a number of factors on the human body during the period when the spacecraft is placed in orbit: noise, vibration, accelerations, great nervous and emotional stress and, during orbital flight, such factors as dynamic weightlessness, hypodynamia, altered gas medium, unusual, aperiodic alternation of "day and night", etc. In spite of the moderate expression of the effects of each factor taken individually, their combined action due to [illegible-tr] and [illegible-tr] may be quite essential. Therefore, the problem of the influence of each factor individually and, particularly, their combination on the functional state of man requires careful study. The [illegible-tr] study is the influence of weightlessness. /1*

The orbital flights which have been preformed and the materials produced by modeling the weightless state by long term hypodynamia while immersed or by bed rest have shown that considerable functional adjustments occur in a number of organs and systems of the human body.

It has been firmly established by the works of a number of authors that weightlessness and hypodynamia lead to essential changes in the indicators of hemodynamics, respiration, the organs of excretion, the analyzer functions, the regulatory system of the organism and various types of metabolism (N. V. Buyanov, et. al., 1967; K. Ye. Panforova et. al., 1967; V. V. Parin et. al., 1967, 1968; V. S. Katnovskiy, 1967; A. A. Korobova and Yu. B. ? Inichenko, 1968; Ye. M. Yuganov et. al., 1963; G. L. [illegible-tr] V. I. Kopanev, 1962; D. L. Myasnikov et. al., 1968; I. V. Fedorov et. al., 1967; R. W. Lawton, 1962; /2
D.E. Graveline, 19?2; E. Muller, 1963; W. F. Neuman, 1960?; Grabiel et. al., 1964; F. B. Vozis, 1968; D. F. Dietlein, 1964; O. Gauer et. al., 1965; Ch. A. Berry, 1967, 1968 and many others). It should be noted that the functional and biochemical disorders observed in many cases were accompanied by

*Numbers in the margin indicate pagination in the foreign text.

essential structural and morphological changes. The depth both of the functional and of the morphological disorders in the investigations performed has depended on the type and individual peculiarities of the organism, the nature of the model used and its duration.

Naturally, the functional and morphological adjustments noted in the systems mentioned above should lead to changes in the total reactivity of the organism, closely related to its resistance. This has been confirmed in experiments to determine the orthostatic stability, tolerance to exhilarations, vestibular stability, sensitivity to infection, the effects of pharmacological preparates and other factors.

Actually, a number of authors have shown clearly that after the completion of space flights by the cosmonauts (O. G. Gazenko, A. ? [illegible-tr], 1965; P. V. Buyanov et. al., 1966; C. A. Berry, 1962; Digiovani, 1964; L. E. Lamb, 1964 and many others), as well as in experiments modeling the weightless state (?. I. Kakurin, B. S. Katkovskiy, 1966; ?. D. Pestov, 1968; B. ?. As?molov, A. D. Voskresenskiy, 1968; L. Kakurin, 1968; A. V. Korobkov et. al., 1968; P. V. Miller et. al., 1964; J. E. Thomas et. al., 1964 and many others) during the performance of the orthostatic test, more expressed changes are observed on the part of the cardiovascular system than in the initial data which in many cases has led to orthostatic collapse.

In our experiments (N. V. Vasil'yev, A. R. Kotovskaya, 1965), as well as in the investigations of other authors (A. R. Kotovskaya et. al., 1967; P. V. Miller, S. D. Leverett, 1965) after extended (20-70 days) hypodynamia, a decrease in the resistance to exhilarations by an average of 1.5-2 G_x has been noted. When subjected to equal values of exhilarations, the test subjects showed a higher functional stress of the principal psychological systems of the organism. Thus, when the test subjects were subjected to exhilarations of 8-9 G_x the mean pulse frequency after hypodynamia was 170 ± 11 beats per minute, whereas during control experiments the same test subjects showed a pulse rate of 149 ± 18 beats per minute. Similar [illegible] were observed in the respiratory indicators. /3

In our experiments (E. V. Lopayev) we noted a decrease in the threshold of stability of the vestibular apparatus in its tolerance to linear exhilarations and rocking for a long time after hypodynamia.

It seems important particularly to establish the fact of the decrease in immuno biological reactivity under conditions of long term hypodynamia. Kraus and Raab (H. Kraus, W. Raab, 1961), Lawton (R. W. Lawton, 1962) and others have shown that strict bed rest in many cases leads to serious complications in the form of pneumonia, aggravation of [illegible-tr] disease, thrombosis of the veins, etc. G. N. Mikhaylovskiy et. al. (1967) noted in their test subjects in experiments involving 62 days hypodynamia cases of rhinolaryngitis, infections of the upper respiratory tract, and periodontitis. In our experiments involving 70 days hypodynamia, we observed complications in the form of acute otitis, [illegible-tr], urethritis and [illegible-tr]. These complications, doubtless, are a result of a decrease in the natural resistance of the organism in its various links. Actually, the works of ?. ?. Kozar' (1966) and G. P. Mikhaylovskiy et. al. (1967) clearly showed that during hypodynamia, a depression of the phagocytic activity of the blood occurs,along with a decrease in the level of properdine, and a deterioration of the lysozyme activity in the gastric juice, plus a decrease in the bactericidal function of the skin. /4

Doubtless, diseases which may arise during flight, as well as the necessity in certain cases of increasing the resistance of the cosmonauts' organisms to extreme factors in the external medium (ionizing radiation, hypoxia, exhilaration, etc.) may require the usage of drugs. As we know, during the flight of the Apollo 7 spacecraft, W. Schirra, D. Eisele, and W. Cunningham were forced to take drugs for therapeutic purposes.

However, it has been established that in prescribing drugs it is quite important to consider the reactivity of the organism, since the same chemical (pharmacological) substance, taken in the same dose, may under certain conditions (with certain functional state of the organism) be of doubtless aid, and under other conditions may do unjustified harm (V. Ye. Velay et. al., 1966). Actually, in experiments with various types of animals it has been established that exposure to long term transverse exhilarations, an increased sensitivity to cardiac glycosides, narcotics and certain other preparates and a decreased sensitivity to analeptics and analgesics are observed; the reaction of the organism to the introduction of vegetative nervous system mediators is changed (V. Ye. Velay et. al., 1964, 1965, 1967; V. V. Parin et. al., 1965). For example, as we can see from Figure 1, the increase in motor activity of white (mice?) after the introduction of phenamine after exhilaration was less sharply expressed then that of control animals,which indicates a decrease in the specific effect of this preparate.

In our experiments, we also produced data indicating a decrease in the analgesic effect of promodol after the effects of transverse exhilaration. For example, in experiments on rabbits it was established that the increase in the latent period of the motor reflex to a painful stimulus after injection of this preparate during the after effect period of exhilaration was either absent or the deviation of this indicator was considerably less sharply expressed (Figure 2). The decrease in the pharmacological effect of promodol under these conditions is also indicated by the results of experiments studying the toxicity of the preparate. Actually, as we can see from Figure 3, the survival rate of animals given lethal doses of this analgesic after exhilaration was higher than in a control group. /5

It has been established in repeated investigations that the reactions of an organism damaged by penetrating radiation to drugs depends on the degree of the radiation sickness, the time of its development, the dose and the nature of the preparate (V. V. Belay et. al., 1961; N. V. Vasil'yev and N. V. Sansonov, 1958, etc.). In some cases we see an increase, in other cases a decrease, while in still other cases we see an inversion of the reaction to the substances used.

A change in the composition of the surrounding gas medium (hypercapnia, hypoxia) also can cause alterations in the reactivity of the organism to pharmacological substances (N. M. Dmitriyeva, 1960; S. N. Sor?nson, L. N. Post???ova, 1952, etc.). We have established that in a gas medium with an increased content of carbon dioxide (3-10%), the stimulating effect of analeptics (caffein, corasole) on the respiration of rabbits is decreased considerably or does not appear at all.

Under similar experimental conditions, the pharmacological effect of fenamin is decreased. This is indicated in particular by the results of a study of the motor activity of white mice upon injection of phenamine under [illegible-tr] conditions and in various media [predisposed?] the animals to the [illegible-tr] gas medium (Figure 4). At the present time, data are available produced both in experiments with animals and in experiments with man indicating that the sensitivity of the organism to pharmacological agents changes after hypodynamia. For example, M. A. Kravchuk and V. G. [illegible-tr] (1968)performed experiments with white mice which indicated that after 37 days of hypodynamia, the entire stage of narcosis after taking barbamyl shows a number of peculiarities; the excitation stage occurs more rapidly, the sleep stage comes more slowly, and the duration of sleep is shorter. On the other hand, in our experiments performed with white mice, hypokinesia lasting 14 and 28 days was accompanied by an increased depth and duration of [illegible-tr] narcosis (V. V. Baley, G. D. Gled) which, obviously, results from the development of processes of internal inhibition in the brain, as noted by R. [illegible-tr] (1968) under actual flight conditions of weightlessness in apes. When strichnine, caffein and phenamine were used in experiments imitating weightlessness with human subjects, a change in the reaction of a number of primary indicators characterizing the function of the cardiovascular system was noted ([illegible-tr], average, final cystolic and pulse pressure, blood volume per beat and per minute, rate of propagation of pulse wave, etc.). /6

The materials available do not allow us practical recommendations, but they do conclusively indicate the importance of performing investigations in these areas.

Thus, even a brief review of the problem, it seems to us calmly indicates that weightlessness and hypodynamia, which will be constant conditions in space flights in the near future, cause an entire range of functional, biological and morphological changes in the organism, leading to a change in its overall reactivity. However, unfortunately, we must admit that this problem has not received its deserved attention until now, particularly the attention of [illegible-tr] and pharmacologists responsible for the determination of the [illegible-tr] medical support of long term space flights. /7

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